TECHNICAL MEMORANDUM

TO: MARY PERREA, FOUR MILE BROOK STREAM TEAM

FROM: BRIAN GRABER, FLUVIAL GEOMORPHOLOGIST, RIVERWAYS PROGRAM

SUBJECT: FOUR MILE BROOK SITE VISIT AND ASSESSMENT

DATE: 12/2/2004

CC: CARRIE BANKS, STREAM TEAM ORGANIZER, RIVERWAYS PROGRAM
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This Technical Memorandum summarizes and provides recommendations developed from an October 21, 2004 site visit to assess portions of the Four Mile Brook watershed in Northfield, Massachusetts. The brook has an active Stream Team interested in pursuing restoration of aquatic and riparian habitat, and protection of property and infrastructure in the watershed. The Stream Team is currently planning native riparian species plantings along a small portion of the brook.

Four Mile Brook is a direct tributary to the Connecticut River, flowing through a 4.8 square mile watershed. The watershed is mostly forested with some residential development and several roads including Four Mile Road which runs along much of the brook. Four Mile Brook is a coldwater stream supporting brook trout and blacknose dace, and it is annually stocked with Atlantic salmon fry. The brook receives some fishing pressure from anglers. The downstream portion of the brook is part of the Living Waters Core Habitats (data maintained by the Natural Heritage and Endangered Species Program) and much of the watershed is part of both Living Waters Critical Supporting Watershed and BioMap Supporting Natural Landscape.

Figure 1. A portion of the lower reaches of Four Mile Brook.

In September 1999, intense precipitation related to Tropical Storm Floyd led to Four Mile Brook reaching what may have been a 10-year flood stage. During the flood, the brook jumped its banks just downstream of a sharp bend and flowed into the adjacent Four Mile Brook Road, scouring the road and causing significant flood damage. A local resident reported finding 3-foot diameter boulders that were transported by the flood.

Current Challenges

- Stream power and potential flood damage
  The power of a brook and hence its potential to do flood damage increases wherever water is able to flow more quickly to the stream. Four Mile Brook generally has steep upland slopes and flows through a narrow valley, both of which contribute to naturally high stream power during floods. Four Mile Brook Road contributes to the stream power by providing an additional conduit for flow directly adjacent to the brook. In addition, land clearing increases the rate of water reaching the stream and increases downstream flood damage potential. Therefore, stream power and flood damage potential is affected by the following:

    - Development – as more land is cleared for development and more forested land is converted to buildings, lawns, driveways, and other more impervious surfaces, less precipitation infiltrates and storm runoff flows more quickly to the stream, increasing stream power.
    - Floodplain Development - streams naturally overtop their banks slightly more frequently than once every two years and therefore any infrastructure within the floodplain is frequently susceptible to damage. Four Mile Brook Road and other infrastructure are within the floodplain of Four Mile Brook and therefore will continue to be susceptible to flood damage.
    - Roads – in addition to acting as impervious surfaces, roads act as conduits, concentrating flow and transporting it directly into brooks particularly where they flow near waterways, such as Four Mile Brook Road along Four Mile Brook.
    - Steep slopes – stream power is directly proportional to the volume of flowing water and the slope of the stream. Therefore, naturally steep slopes increase stream power. Channel straightening also increases stream power as the same flow travels over a shorter distance of straightened stream and hence a steeper slope. A portion of Fisher Brook, a tributary to Four Mile Brook, appears to have been straightened and may increase overall stream power.
    - Lack of flow breaks – in more natural streams, material such as fallen trees, fallen branches, and leaf litter act as flow breaks, slowing the flow of water to streams and through streams and therefore decreasing stream power. Large woody debris is also an important form of habitat for many species. Four Mile Brook has some limited amount of large woody debris within the channel, but more in the uplands could help slow flow paths. In addition, much of the land was probably cleared during the 19th century, and the relatively young age of the forest means that there is less ground litter and debris to break up the flow.

- Road runoff
  Along with concentrating flows, roads transport sediment and other contaminants and deposit those materials into streams, particularly where the roads are adjacent to the stream and the road runoff

paths are directed toward the stream. Four Mile Brook Road may be a significant source of sediment to the brook. While the high stream power appears to clear much of this material from most of Four Mile Brook, it probably deposits downstream near where Four Mile Brook connects with the Connecticut or it ends up in the Connecticut.

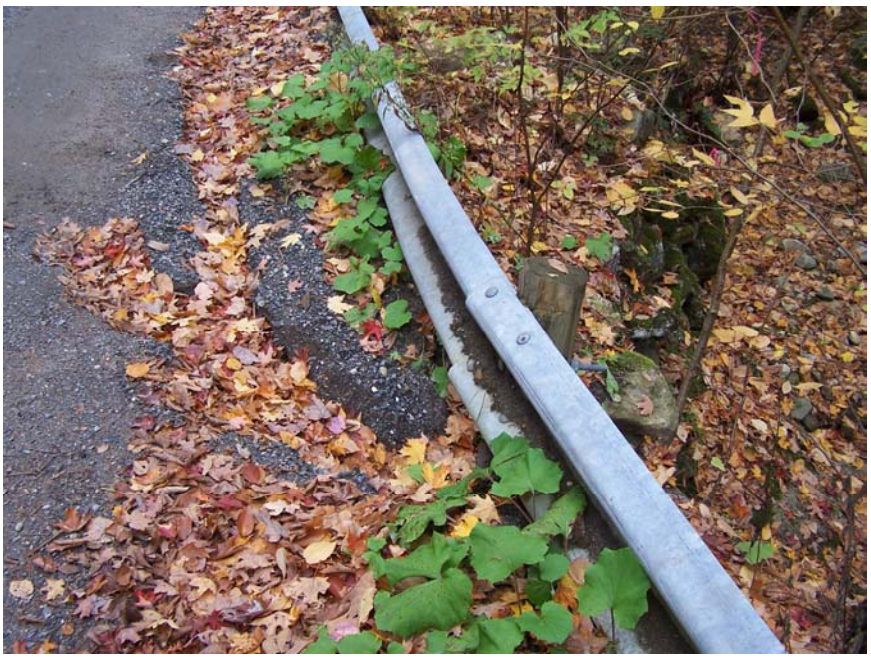

Figure 2. The drainage pattern along this road sends road runoff directly into Four Mile Brook carrying sediment and other contaminants from the road.

- Riparian buffers
  Vegetated riparian buffers help protect streams from runoff and sediment, decrease bank erosion, and provide shade and cover for a range of species. Along much of Four Mile Brook Road, the buffer appears to be inadequate to provide significant benefits and in some areas grass appears to be mowed right up to the edge of the brook. Elsewhere, buffers along the stream appear to be well vegetated and effective.

- Habitat fragmentation – stream crossings
  Roads can act as barriers to fish and wildlife movement where culverts are insufficiently sized or insufficiently set into the stream bed to allow passage. At least two culverts along Four Mile Brook Road appear to be acting as a barrier to some species.

- Dams
  Dams can have a significant effect on streams by fragmenting habitat and reducing water quality, and small dam failures during floods can increase flood waves and thereby increase damages. Water warms as it sits impounded behind dams under the summer sun and this warm water is released downstream unless the dam has a large reservoir with water released from the lower part of the reservoir. This warming effect can significantly impact the survival of coldwater species such as trout and additionally depletes the dissolved oxygen content of the water because warmer water holds less oxygen. In addition, dams trap sediment and nutrients, which can result in excessive vegetation and further dips in oxygen levels as plant material decays and nocturnally respires. That said, the impact of dams on Four

Mile Brook is unclear. The state database includes only one dam in the watershed, the Northfield Mountain Reservoir Dam. However, a small dam, not in the database, is readily visible from Four Mile Brook Road. In addition, air photos indicate that there may be several other dams scattered throughout the upper portions of the watershed.

Figure 3. A portion of Four Mile Brook lacking a sufficient vegetated buffer. Four Mile Brook Road is immediately to the left of the photo.

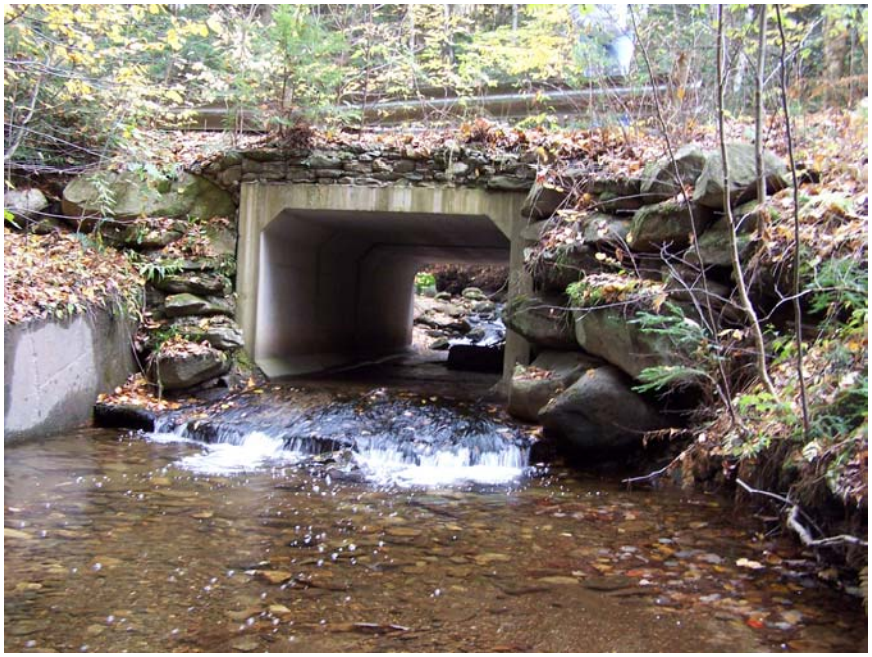

Figure 4. A box culvert under Four Mile Brook Road is partially "perched" on the downstream end, impeding fish passage.

Figure 5. A small dam off the main channel in the lower reaches of Four Mile Brook. Water is diverted from the mainstem of the brook into the impoundment behind this dam.

- Other habitat issues
    - Bluff erosion – because Four Mile Brook flows closely to the valley sides in areas, the high erosional power of the flow can cause excessive erosion. As the toe of slopes erodes away, the entire slope face can end up eroding into the stream. One such slope was noted in the lower watershed and there may be others. Bluff erosion is potentially a significant source of sediment into the stream that will ultimately deposit in the lower reaches of the brook or in the Connecticut River.
    - Scour – field evidence indicates that normal bankfull flows (generally slightly less than the 2-year flood) transport cobble sized stones (approximately 100 mm) in the lower portions of the watershed. This is additional evidence of the stream power in the watershed and depending on the timing of these flows they could scour out important habitat features such as spawning beds.
    - Failing riprap – riprap placed to protect Four Mile Brook Road just upstream of where the road failed is falling into the stream. The failing riprap is isolated and does not seem to be creating a significant habitat problem, but other bioengineering stabilization techniques or combinations of bioengineering with "hard" engineering could provide protection for the road and banks and provide additional riparian habitat.

Figure 6. An eroding bluff along Four Mile Brook has likely resulted from the stream power eroding away the toe of the slope until the slope collapses into the stream. Portions of the brook flow along one or both valley walls.

Figure 7. Rock riprap placed to reduce erosion on an outer bend of Four Mile Brook is partially collapsing into the stream. The brook jumped the bank just downstream of here during the September 1999 flood.

General Recommendations

- Watershed Assessment

  A more comprehensive watershed assessment of Four Mile Brook would be extremely worthwhile, particularly because of the combination of both habitat challenges and potential property and infrastructure damages. The habitat challenges raise the priority of a watershed assessment particularly because the state has identified much of the watershed as Living Waters Critical Supporting Habitat, BioMap Supporting Natural Landscape, and Living Waters Core Habitat; and the brook is part of state and federal Atlantic salmon restoration efforts. Property and infrastructure challenges also raise the priority of a watershed assessment because the stream power of the brook has already caused significant damages. The watershed assessment would comprehensively analyze factors that are threatening habitat, increasing stream power, and increasing potential for damages to property and infrastructure, such as:

    - Landuse impacts on flooding (modeling changes with new development)
    - Relative sources of sediment (road runoff, cleared land, bank erosion, bluff erosion, remobilization)
    - Habitat connectivity through road crossings and dams
    - Impacts of dams on water quality
    - Relative locations of stream power
    - Effectiveness of riparian buffers
    - Quality of habitat (biotic integrity, large woody debris, bed and bank features)

- Management Plan

  With expected increases in development in the upper watershed, a management plan could help guide development to have the least impacts on the stream corridor both short-term during construction and long-term from increased runoff and impervious area. A management plan would be worthwhile for protecting downstream property and infrastructure as well as for habitat. Using the information analyzed in a watershed assessment, a management plan could be developed to:

    - help guide thoughtful development
    - provide management practices for construction
    - provide management practices for roads and road crossings including plans to retrofit or replace ineffective crossings
    - reduce stream power and erosion
    - protect and proactively restore habitat

Figure 8. New development in the upper portions of Four Mile Brook. Thoughtful management can minimize the impacts of development, which typically include increased flood power and sediment load.

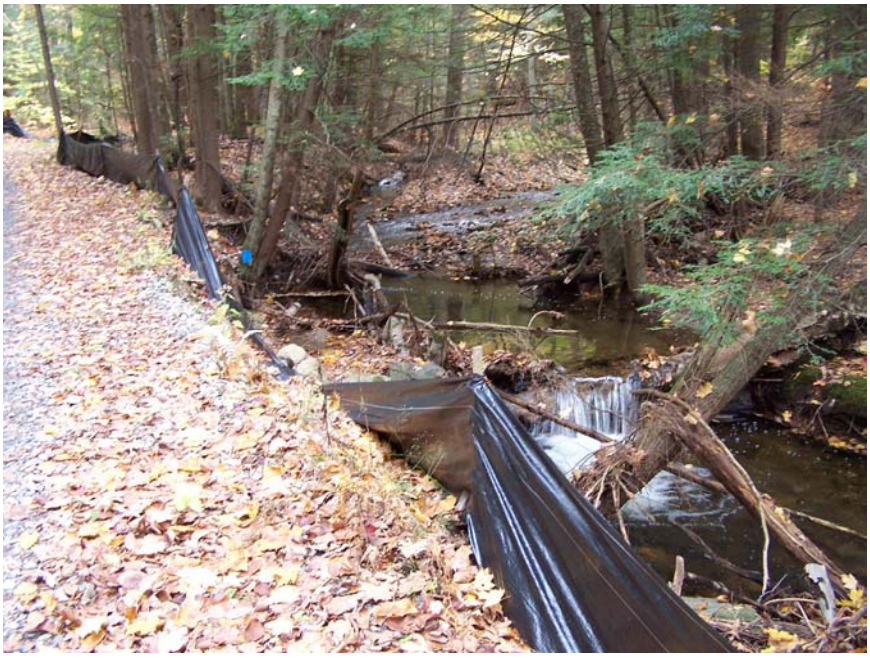

Figure 9. A collapsing silt fence is limiting its ability to protect Four Mile Brook from nearby construction runoff.